Ultrasonic Sampler Development

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Honeybee Robotics

NASA ASTEP Program Conference

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DEVELOPMENT TEAM

HONEYBEE ROBOTICS	Paul Bartlett Tom Myrick Seth Frader-Thompson	System design Sampling design Sample transfer mechanism Environmental testing
JPL	Yoseph Bar-Cohen Xiaoqi Bao David Braun Zensheu Chang Stewart Sherrit	Ultrasonic drill development Mathematical modeling Sampling design Testing support
CYBERSONICS	Tom Peterson	Control electronics support for ultrasonic actuator
Ames Research Center	David Blake	Requirements derivation Chemin XRD/XRF instrument

PURPOSE

Produce a low-force drilling based sampling system and demonstrate at TRL 6

- Further ultrasonic drill development and modeling
- Automation of drilling / sampling
- Addition of autonomous sample delivery for analysis
- Direction of design towards analysis instrument accommodation
- Environmental testing

CHEMIN

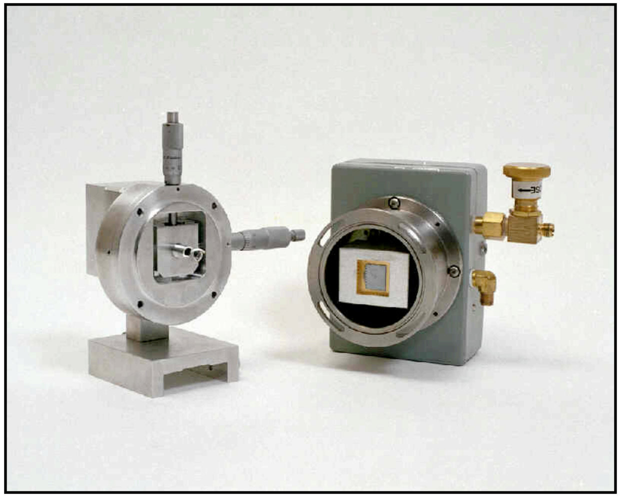
A Miniaturized Simultaneous X-ray Diffraction / X-ray Fluorescence Instrument

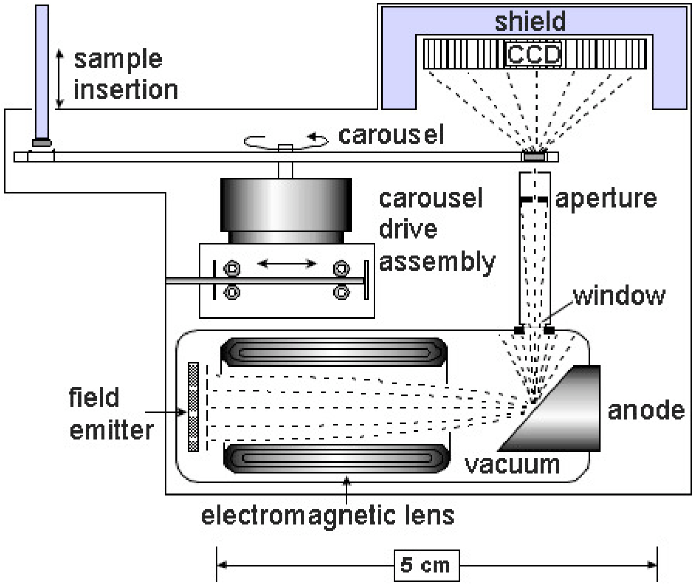
The XRD instrument will be used to search for definitive evidence of past or present water activity through analysis of rocks containing

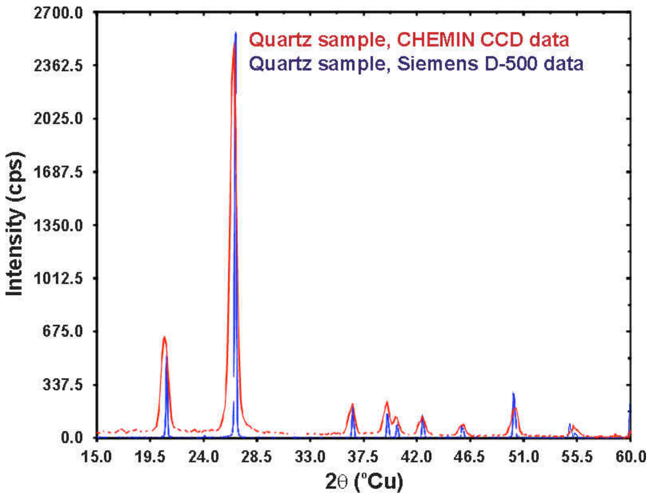
- Hydrated minerals
- Clastic sediments
- Hydrothermal precipitates and chemical sediments.

The elucidation of the nature of the Mars soil will require the identification of mineral components that can unravel its history and the history of the Mars atmosphere. Examples include:

- Cement components of the soil
- Iron-magnetic component
- Oxidative component
- Global/local dust and soil units

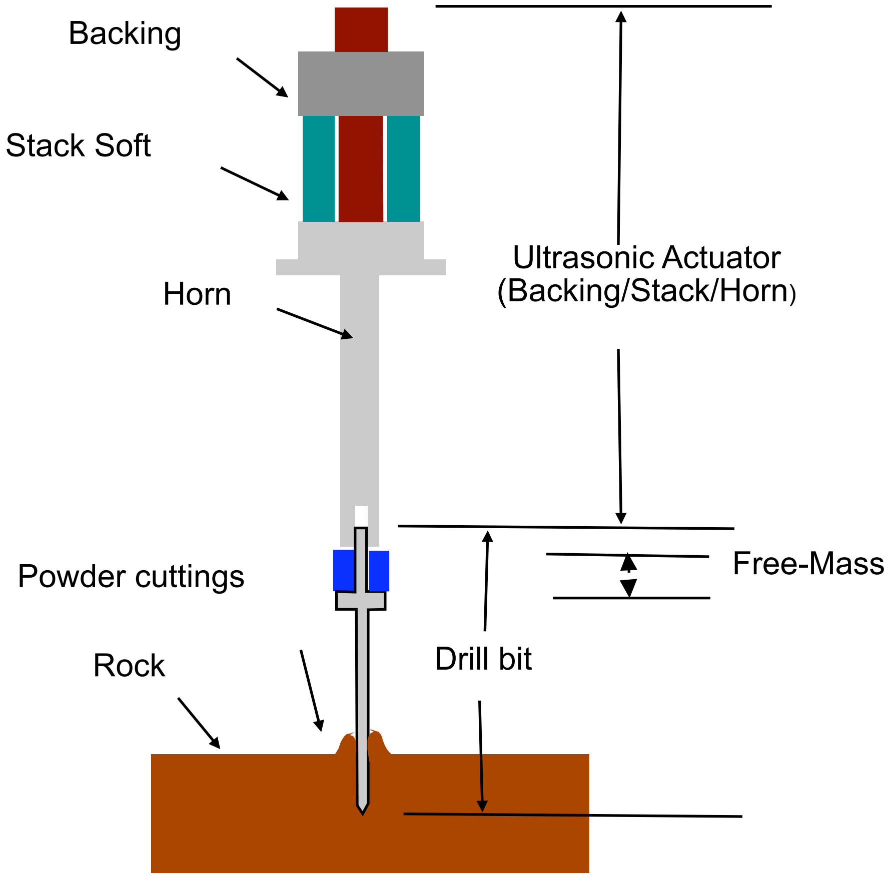




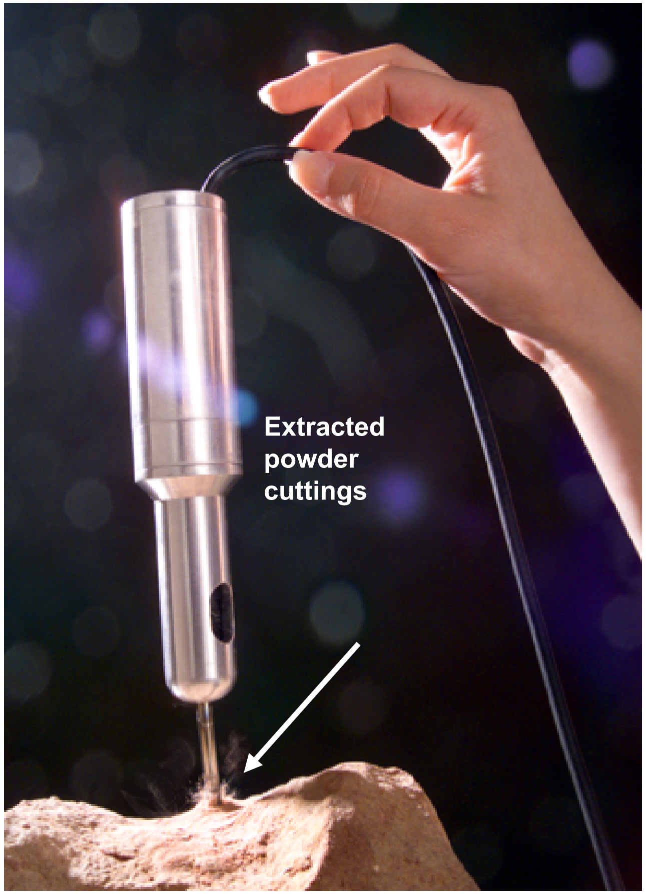


** From Los Alamos National Lab Chemin website, Blake et al*

ULTRASONIC DRILL TECHNOLOGY



A schematic view of the USDC components



The USDC is shown to require relatively small preload to core a rock.

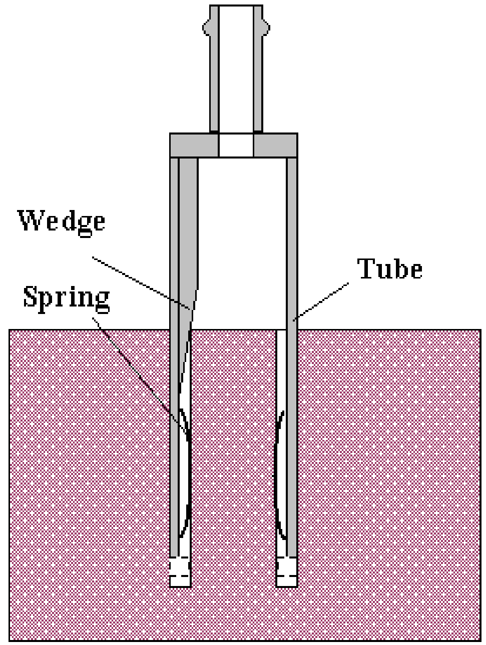
DRILL DEVELOPMENT

- Design iterations
- Further mathematical modeling of drill
- Integrate sampling method
- Develop autonomous drilling, via force sensing and closed loop control
- Facilitate sample hand-off
- Design towards flight readiness

SAMPLING DEVELOPMENT

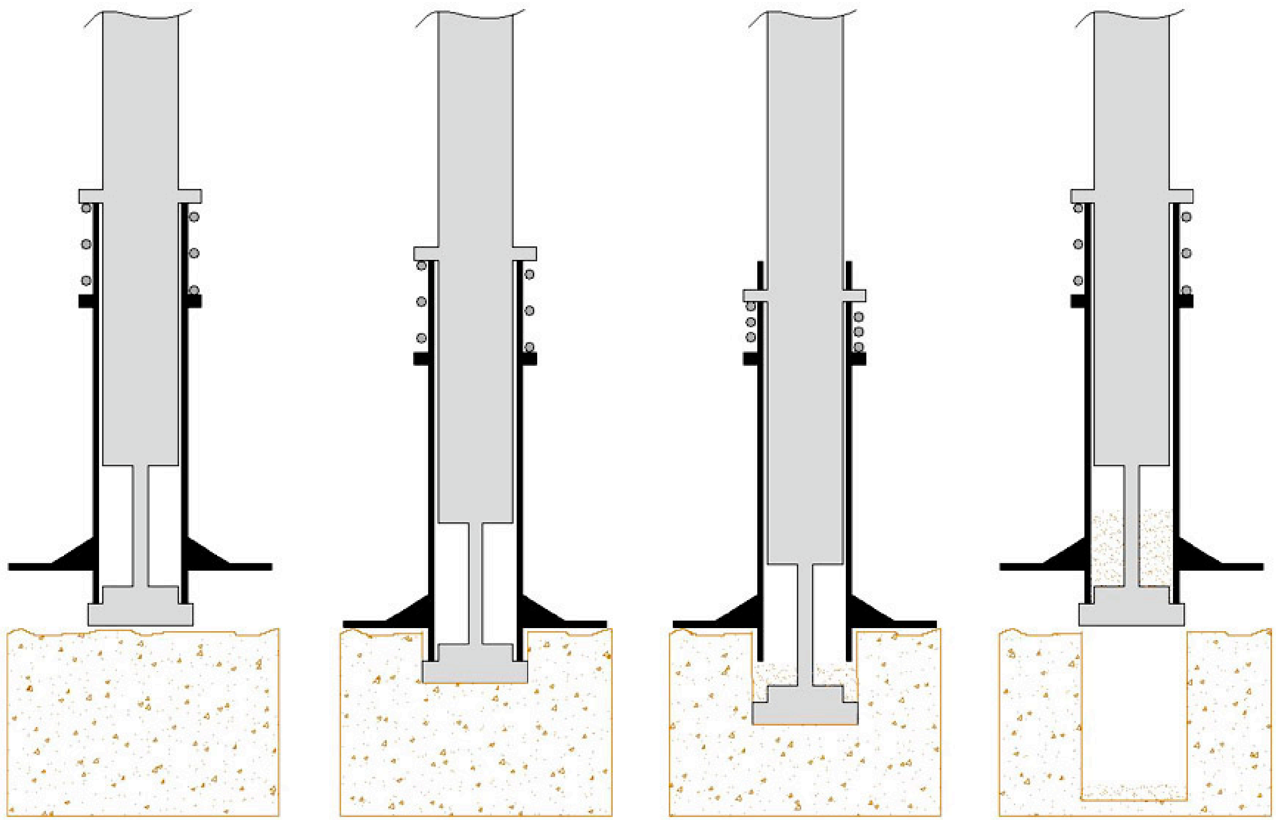
- USD is capable of core or powder sampling
- Powder sampling seems appropriate for XRD and multiple other instrument types, i.e. sampling of cuttings produced by penetrating the rock
- Could employ pneumatic methods of collecting cuttings (compressed CO_2 for example on Mars)
- Could be passively actuated/collected in bit
- Both core and powder collection could be accomplished simultaneously to accommodate different instruments
- Intend to collect sample from depth below the rock surface

CORE SAMPLING



A schematic view and solid model of the all-in-one core extraction bit

POWDER SAMPLING



Sleeve travels with Bit, Spring-loaded down.

Bit penetrates weathered layer. Sleeve flange contacts surface.

Bit continues to penetrate. Sleeve is hardstopped so cavity opens.

Bit retracts. Sleeve closes retaining loose sample from proper depth.

SAMPLE DELIVERY

- The means will be developed to transfer powder and/or cores to an instrument or instruments
- Embedding active mechanisms in the USD may prove infeasible
- A separate mechanism would transfer sample from the USD bit to the XRD
- Design is heavily dependent on spacecraft platform
- Transfer mechanism could also perform other tasks
  - Cleaning the USD bit to avoid cross-contamination or
  - Removing analyzed sample from the instrument
  - Caching samples in a sample return mission

SYSTEM DESIGN

- Integrate drill, transfer mechanism & instrument
- Incorporate principles of robotics and automation, such as position information, hand-offs, and reliability
- Consider likely spacecraft platforms and environments
- Address flight design concerns such as mass, volume, materials, robustness, etc.

LABORATORY TESTING

- Produce and test multiple elemental and system breadboards
- Investigate all phases: drilling, sampling, and transferring
- Test from stiffness and mass model platform
- Sample an array of Mars and other analog rocks
- Refine system requirements
  - Platform stiffness, mass, software control
- Monitor induced environments
  - Vibrations, forces, generation of powder

Honeybee Robotics rock library

ENVIRONMENTAL TESTING

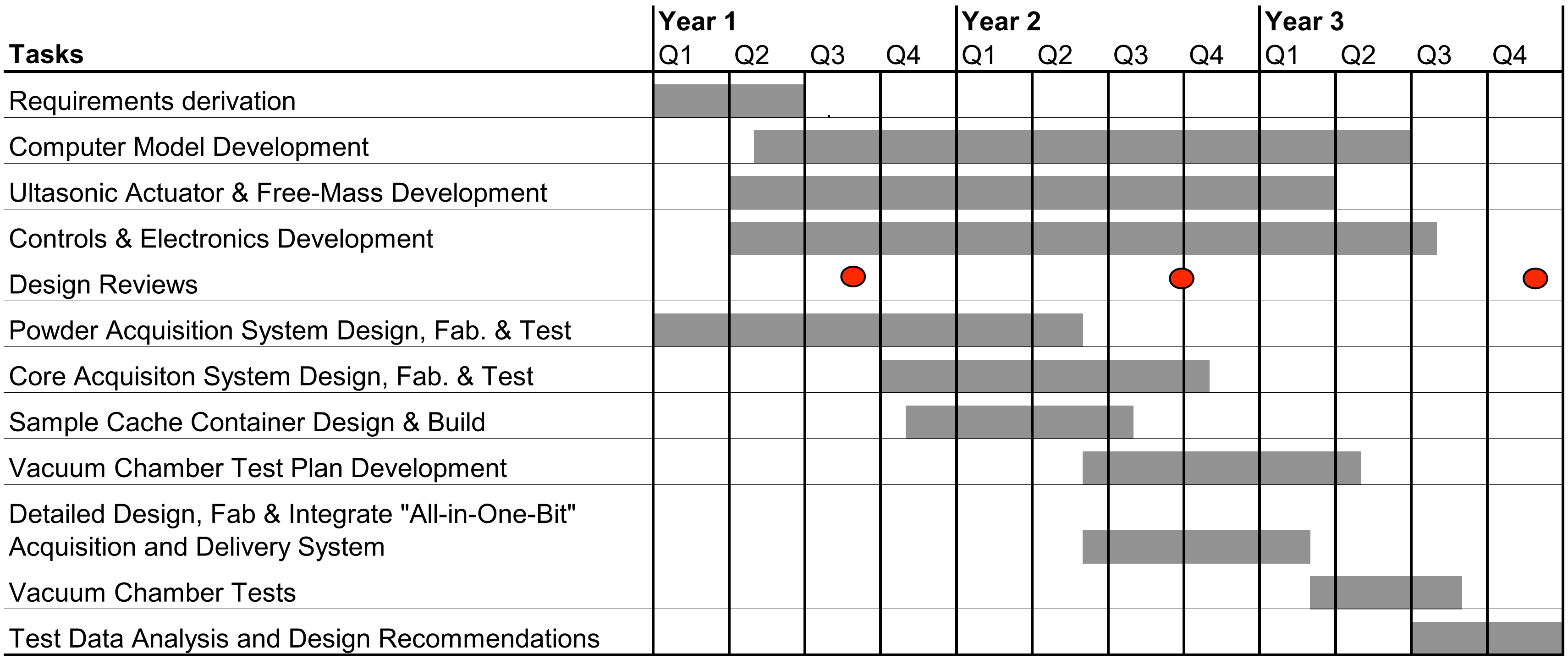
Will test breadboards in Mars environments to achieve TRL6

Will operate components and system in thermal/vac chamber at Honeybee Robotics

- Samples: dried (de-hydrated) analog rocks
- Fines: Down to 10 μm and smaller analog fines coating rocks
- Thermal: to -55ºC and colder
- Vacuum: to 7 mbar and lower

Honeybee Robotics thermal/vac chamber

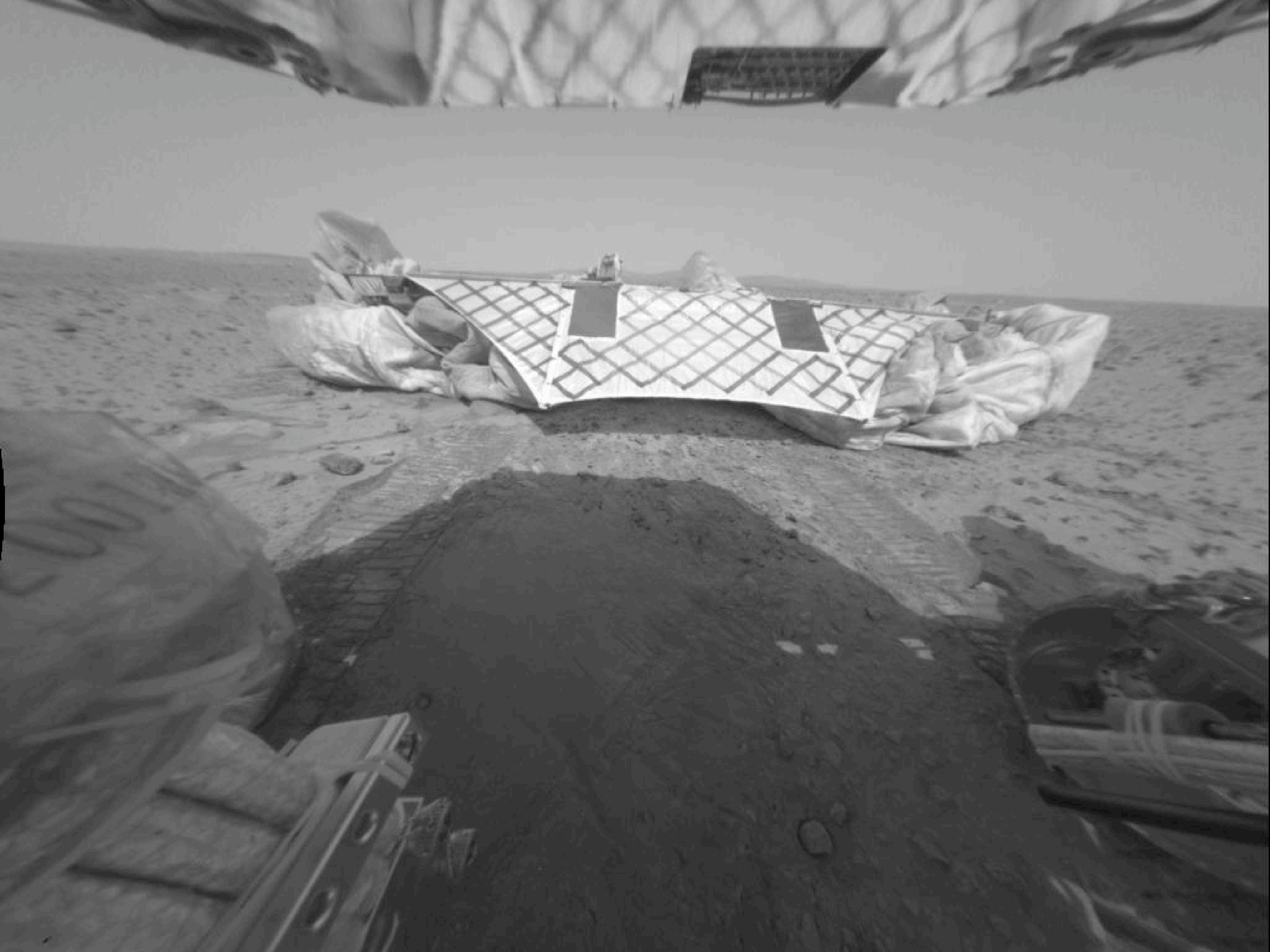
MILESTONES

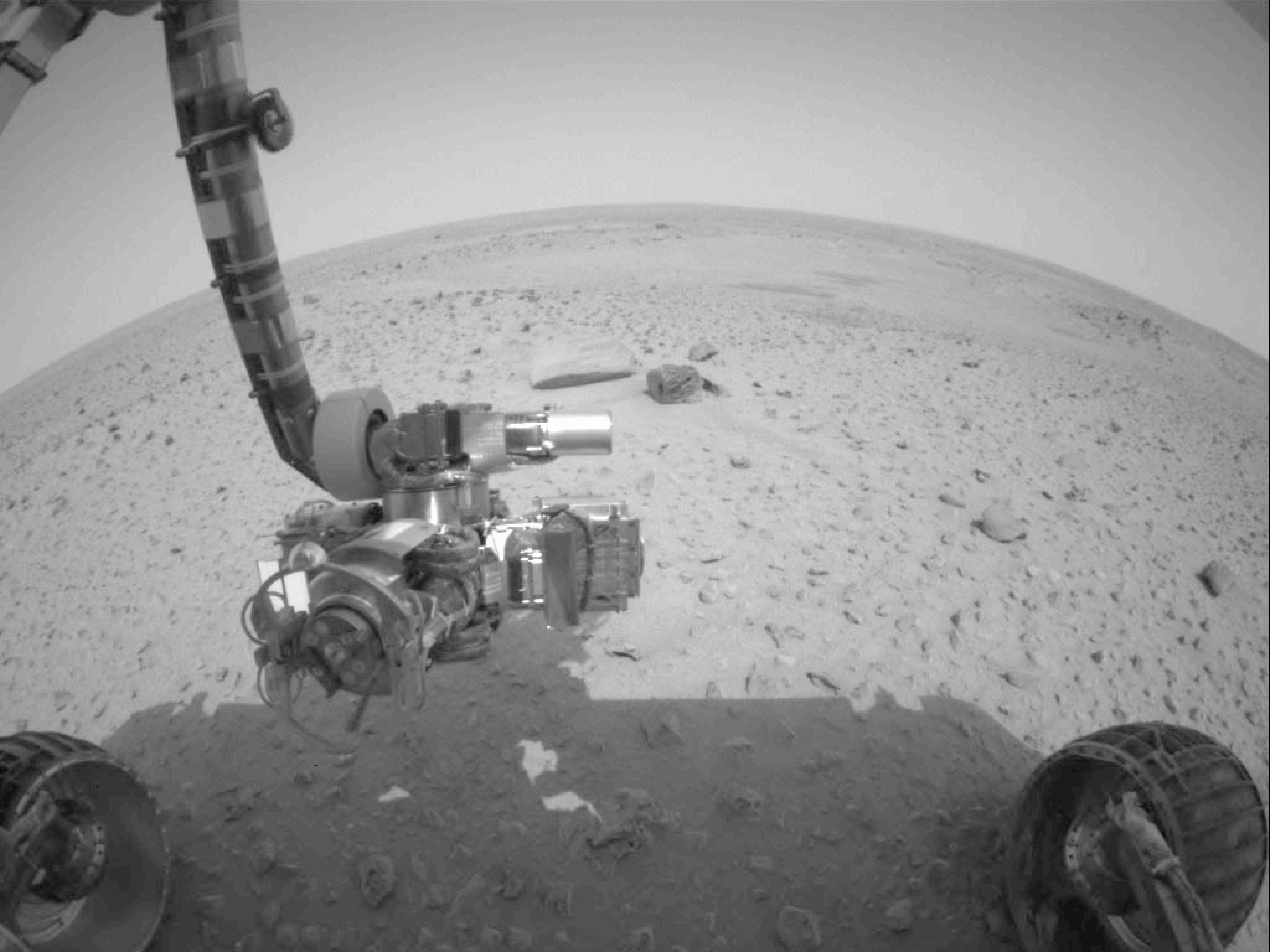

Tasks
Year 1
Year 2
Year 3
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Requirements derivation
Computer Model Development
Ultasonic Actuator & Free-Mass Development
Controls & Electronics Development
Design Reviews
Powder Acquisition System Design, Fab. & Test
Core Acquisiton System Design, Fab. & Test
Sample Cache Container Design & Build
Vacuum Chamber Test Plan Development
Detailed Design, Fab & Integrate "All-in-One-Bit" Acquisition and Delivery System
Vacuum Chamber Tests
Test Data Analysis and Design Recommendations

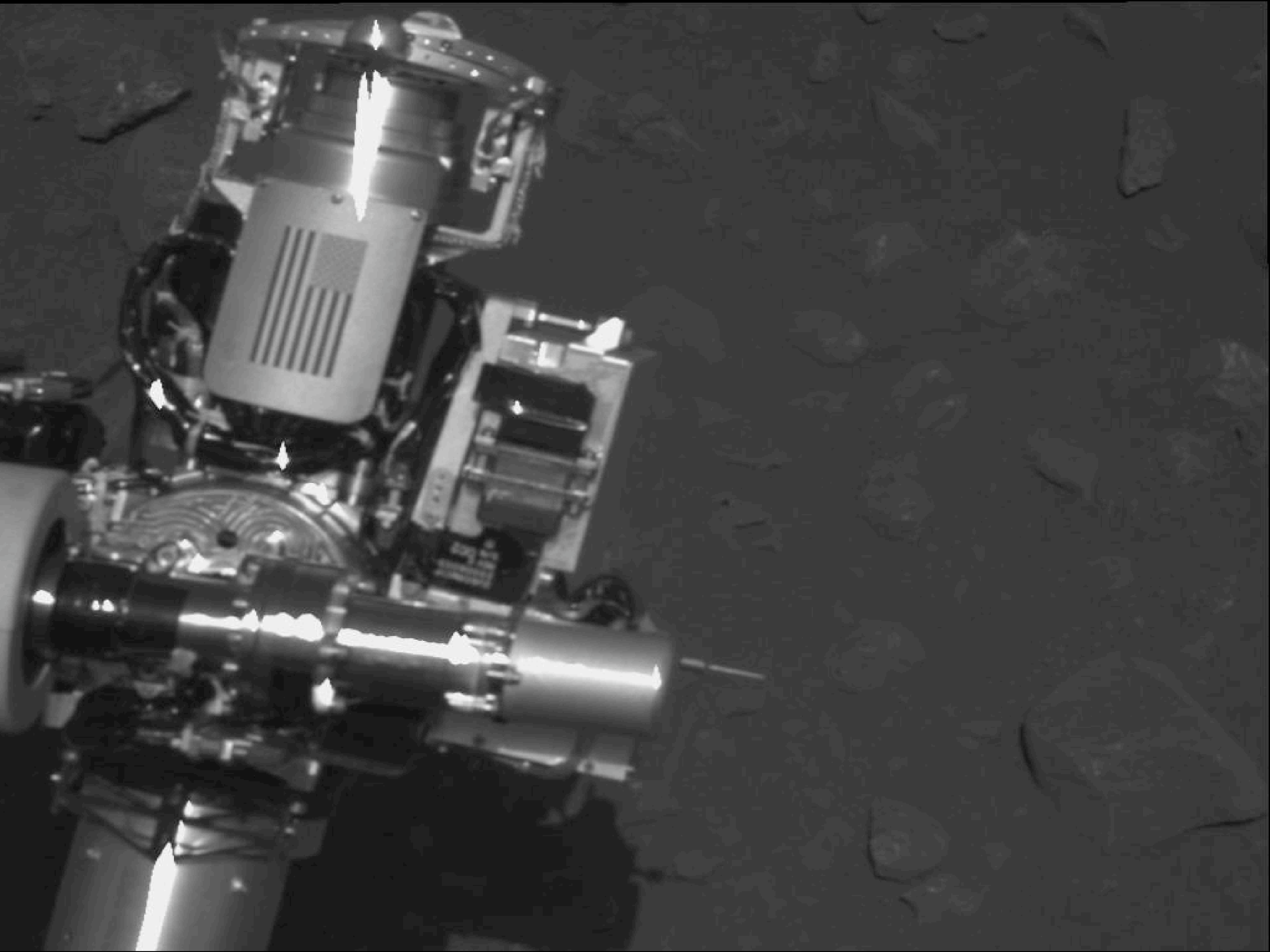
MISSION APPLICABILITY

Low force drilling

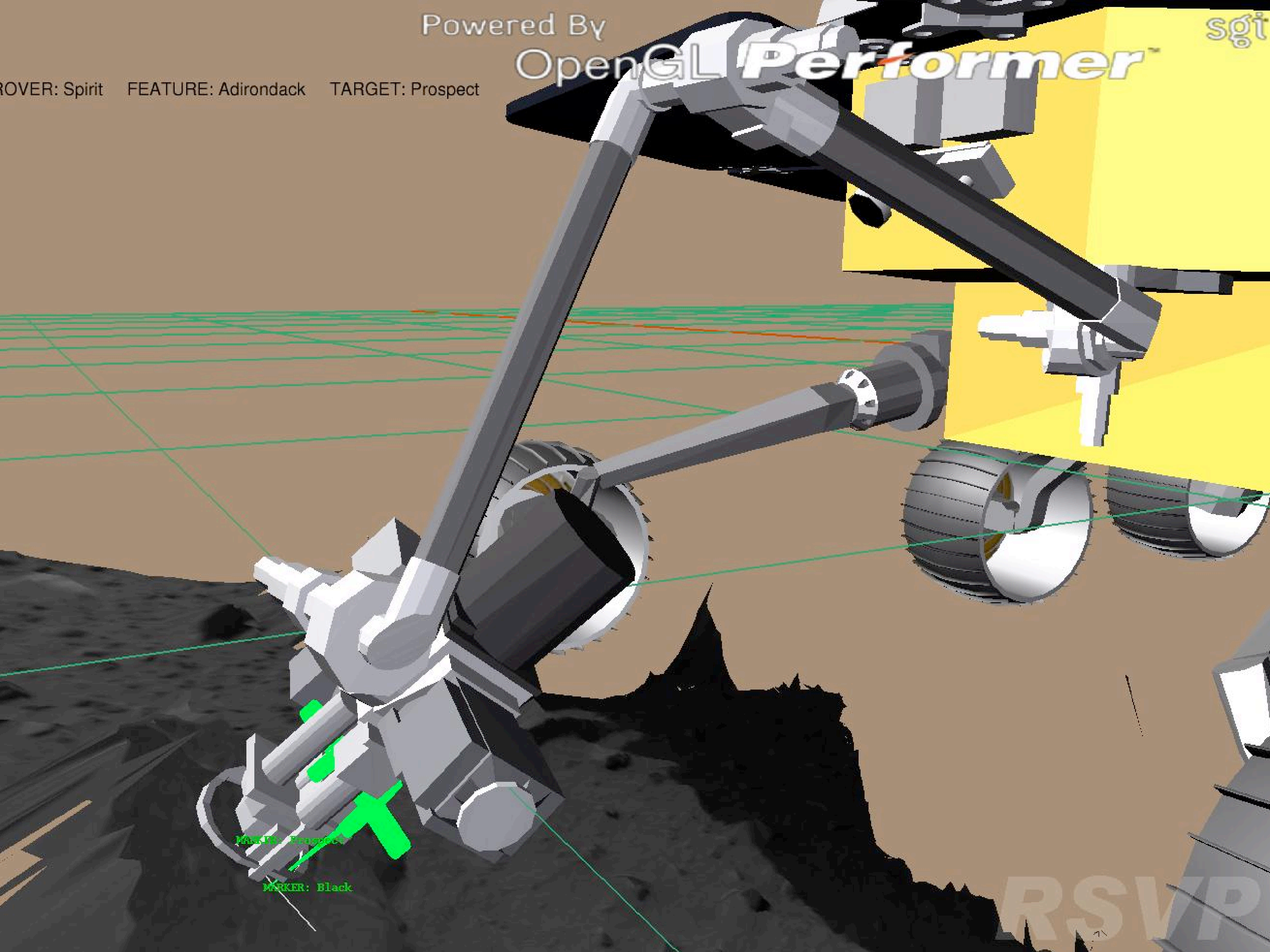
- Small vehicles on planets and large moons: lower cost Mars rovers
- Drilling from a robotic arm or other low strength manipulator
- Small celestial bodies with low gravity: comets, asteroids







Adirondack


Powered By
OpenGL Performer
sgi
ROVER: Spirit
FEATURE: Adirondack
TARGET: Prospect
MARKER: Black
RSVP

FILE INFORMATION

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